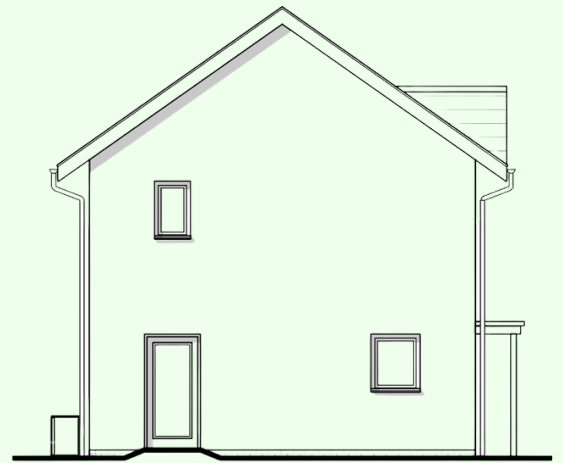




PHPP MODELLING AND NET ZERO IMPROVEMENT REPORT HT641 NEW-BUILD DWELLING

Building Services 2 - Integration (ACBA5017)

Prepared for

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Executive Summary

This report assesses the HT641 new-build domestic dwelling using the baseline PHPP model, project drawings and the Vale of Glamorgan Net Zero Carbon Buildings feasibility specification (Spring Design, 2024a; King, 2026a; King, 2026b). The purpose of the report is to review the existing compliant fabric and M&E strategy and identify how the dwelling can be improved to achieve a low-energy / Net Zero-ready standard.

The HT641 dwelling is a two-storey, four-bedroom, six-person house with a measured gross internal area of 110.4 m². The dwelling has a compact form, a pitched roof, coordinated plant allowances and a due east-west orientation, with the front elevation treated as east-facing and the rear elevation as west-facing. The baseline design includes good new-build fabric U-values, photovoltaic panels, a generic ASHP, double glazing, mechanical extract ventilation and simple on/off controls.

Although the baseline is a reasonable compliance-led specification, it does not fully represent a high-performance Net Zero-ready dwelling. The main weaknesses are air permeability, thermal bridge allowance, extract-only ventilation, double glazing, generic heat pump performance and basic controls. These issues increase heating demand and reduce the effectiveness of the low-carbon services.

The proposed upgrade strategy follows a fabric-first approach before optimising services. The upgraded PHPP model improves airtightness, thermal bridging, glazing, ventilation, heat pump distribution and controls, while retaining the existing PV provision. The final upgraded model achieves Passive House Classic verification, with a space-heating demand of 15 kWh/m²a, heating load of 10 W/m², airtightness of n50 0.6 1/h, overheating frequency of 5%, PER demand of 47 kWh/m²a and renewable generation of 71 kWh/m² footprint (King, 2026b). This demonstrates that the HT641 dwelling can meet a high low-energy standard when the baseline design is improved through coordinated fabric and M&E upgrades.

1.0 Introduction and Scope

This report has been prepared for the Building Services 2 – Integration assignment. The task requires the existing M&E system design for a new-build domestic dwelling in Wales to be identified, critically appraised and improved to meet the needs of a low-energy / Net Zero design approach (UWTSD, 2026). The report also requires the dwelling to be modelled using suitable energy analysis software, with the model outputs used to justify the final design decisions.

The report focuses on the HT641 dwelling. PHPP has been used as the main modelling tool because it allows fabric heat loss, airtightness, ventilation, glazing, solar gains, overheating, heating systems, domestic hot water and PV generation to be assessed in a consistent way (Passive House Institute, 2024). The baseline model is used as the reference point, with an upgraded model developed to test whether the dwelling can achieve a more ambitious low-energy standard.

The assessment considers building form, orientation, baseline fabric, M&E strategy, PHPP results, proposed upgrades, cost, carbon, maintainability and the performance gap. This is not a full construction design package. Final product selection, installation details, commissioning values and cost information would need to be confirmed by specialist designers, manufacturers and installers before construction.

2.0 Building Assessment

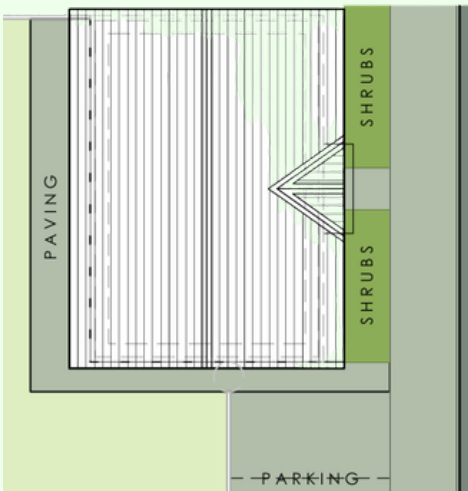


FRONT ELEVATION



RIGHT SIDE ELEVATION

DUE EAST-WEST
ORIENTATION

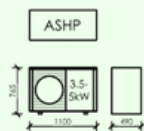


The HT641 dwelling is a two-storey new-build domestic property. The supplied floor plan identifies it as a four-bedroom, six-person house with a measured GIA of 110.4 m². The layout includes a lounge, kitchen/dining space, WC/shower, utility, store, bathroom, landing, airing cupboard and four bedrooms (Spring Design, 2024b).

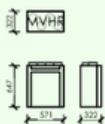
The building form is simple and compact, which is beneficial from an energy perspective because it reduces external envelope area relative to the internal floor area. This helps limit heat loss and makes the dwelling suitable for a fabric-first low-energy strategy. The elevations show a conventional domestic appearance with windows to the front, rear and side elevations, a small front porch/door overhang and an external ASHP position with required clearance zones.

The notional site layout identifies the dwelling as having a due east-west orientation (Spring Design, 2024d). The central dwelling on the layout is the unit modelled in PHPP. The front elevation has been treated as east-facing and the rear elevation as west-facing, with the side elevations facing north and south. This matters because PHPP relies on correct orientation when calculating solar gains, heat losses and overheating risk.

The project drawings also identify plant allowances for an ASHP, ventilation unit and hot water cylinder (Spring Design, 2024c). Although the drawings include an MVHR plant allowance, the baseline operational specification uses mechanical extract ventilation (MEV) (Spring Design, 2024a). For this reason, the baseline PHPP model uses MEV, with MVHR introduced later as part of the upgraded low-energy strategy.



Vaillant aroTHERM plus 5 kW
dimensions: 765x1100x490mm (hwd)



envirovent energiSava 200
dimensions: 647x572x322mm (hwd)

Volume flow: 40-245m³/h
Heat recovery: 89.0%
Specific fan power: 0.79W/l/s

3.0 Baseline PHPP Model

The baseline PHPP model represents the dwelling before the low-energy upgrade package is applied. It is based on the AD L Wales-style operational scenario within the Vale of Glamorgan specification (Spring Design, 2024a). This includes good fabric U-values and existing PV provision, but less ambitious airtightness, ventilation, glazing and services inputs.

Element	Baseline Specification
Air permeability	5.00 m ³ /m ² /hr
Thermal bridges	0.200 W/mK
Window frames	Uf 1.400 W/m ² K uPVC
Glazing	Ug 1.120 W/m ² K double low-e glazing, 16mm argon
Glazing g-value	0.64
Glazing edge	0.040 W/mK
Ventilation strategy	MEV
Heat recovery	None
Ventilation rate	30m ³ /person/hr
Heating	Generic ASHP
SCOP	3.3
Controls	On/off
PV	Included in baseline model

The baseline values are taken from the Vale of Glamorgan operational specification and baseline PHPP model (Spring Design, 2024a; King, 2026a).

The baseline design has some positive features. It already uses an electric ASHP instead of fossil-fuel heating, includes PV and has relatively good new-build fabric U-values. However, the baseline PHPP result showed a space-heating demand of approximately 77.4 kWh/m²a (King, 2026a), which is well above the 15 kWh/m²a Passive House heating demand criterion. This confirms that the baseline is compliant but not high-performance. It also shows that good U-values alone are not enough where airtightness, thermal bridging and ventilation heat recovery remain weak.

The main performance risks are avoidable heat loss through air leakage, extract-only ventilation and thermal bridging. The double glazing is acceptable as a compliance measure but does not provide the same comfort or heat-loss reduction as triple glazing. The generic ASHP and on/off controls also limit operational performance, particularly when compared with a low-temperature, weather-compensated heat pump strategy.

4.0 Low-Energy / Net Zero Design Standard

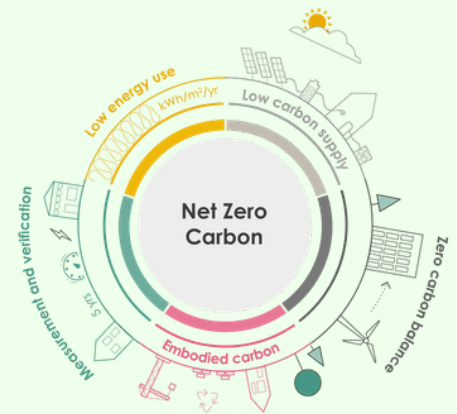
The proposed improvement strategy uses a LETI-style Net Zero-ready approach, supported by UKGBC and Passivhaus principles (LETI, 2020; UKGBC, 2019; Passivhaus Trust, 2013). This is suitable because the assignment asks for improvement beyond minimum compliance, and the Vale of Glamorgan specification compares AD L, AECB CarbonLite, B&NES and LETI operational scenarios. Building Regulations are therefore treated as the baseline rather than the final performance target (Spring Design, 2024a).

The LETI scenario is the most ambitious of the listed operational scenarios, targeting a space-heating demand of 15 kWh/m²a and an Energy Use Intensity of 40 kWh/m²a (Spring Design, 2024a; LETI, 2020). The project specification notes that the basic fabric U-values are already high quality, meaning the main differences between scenarios are achieved through improved build quality, airtightness, thermal bridging, window/door specification and services efficiency.

In this report, Net Zero-ready means reducing operational energy demand as far as reasonably practicable before using PV to offset the remaining electrical demand. The design approach therefore follows a clear hierarchy:

- 1.Reduce heat demand through airtightness, glazing and thermal bridge detailing.
- 2.Replace extract-only ventilation with MVHR.
- 3.Improve heat pump operation through low-temperature distribution and better controls.
- 4.Retain PV to offset remaining electrical demand.
- 5.Check overheating, maintainability and whole-life implications.

This avoids relying on PV alone. PV is important, but it should not be used to compensate for avoidable fabric and ventilation losses. The fabric-first approach prioritises reducing energy demand through the building envelope before relying on services and renewable technology (LETI, 2020; Passivhaus Trust, 2013). Once demand is reduced, the ASHP can be sized more accurately and operate more efficiently. This also reduces running costs, improves comfort and gives the building greater resilience against future energy price increases.



FABRIC FIRST

TAKING A FABRIC FIRST APPROACH TO REDUCING THE ENERGY CONSUMPTION. REVIEW OF APPROPRIATE SYSTEMS WITH THE RIGHT PROCESS FOR THE SPECIFIC PROJECTS.



5.0 Baseline Fabric and M&E Appraisal

The baseline design is a strong starting point because it already includes PV, an ASHP and good fabric U-values (Spring Design, 2024a). However, it should be viewed as a compliance-led design rather than a full Net Zero-ready specification.

The main fabric weakness is airtightness. A permeability of 5.00 m³/m²/hr is not suitable for a high-performance dwelling because uncontrolled air leakage increases heating demand and reduces comfort. Thermal bridging is also significant, with a baseline allowance of 0.200 W/mK. This suggests that key junctions such as window reveals, slab edges, eaves, gables, corners and party wall junctions require more careful detailing.

The baseline ventilation strategy is also limited. MEV extracts warm internal air from wet rooms but does not recover heat (Welsh Government, 2022a; Spring Design, 2024a). As airtightness improves, ventilation must become deliberate and controlled rather than relying on leakage paths. MVHR is therefore better suited because it supplies fresh air to habitable rooms and extracts from wet rooms while recovering heat.

The baseline ASHP also requires refinement. A generic ASHP with on/off control does not fully reflect best practice. Heat pumps perform best with low flow temperatures, correctly sized emitters, weather or ambient compensation and stable operation (Passivhaus Trust, 2024; Vaillant Group UK Ltd., 2019). The upgraded design therefore retains the ASHP principle but improves the distribution strategy and controls.

6.0 Proposed Upgrade Strategy

The proposed upgrade strategy moves the dwelling from an AD L-style baseline towards a LETI / Passive House Classic standard. The overall design intent remains the same, but the quality of the fabric and services is improved.

Measure	Baseline	Upgrade	Reason
Airtightness	5.00 m ³ /m ² /hr	n50 0.6 1/h	Reduce uncontrolled heat loss
Thermal bridges	0.200 W/mK	-0.050 W/mK	LETI-level junction detailing
Glazing	Double glazing	Triple glazing	Reduce heat loss and improve comfort
Ventilation	MEV	MVHR	Recover heat and control IAQ
Heat pump distribution	55°C	45°C	Improve ASHP performance
Controls	On/off	Ambient/weather compensation	Improve seasonal operation
PV	Existing	Retained	Fair baseline comparison

The upgrade package was developed in stages so that each measure could be linked back to the PHPP performance outcome. The table below summarises the main modelling changes and the intended impact of each measure.

Upgrade Stage	Purpose	Result / Impact
Baseline	AD L-style starting point	77.4 kWh/m ² a
Airtightness improved	Reduce infiltration loss	n50 0.6 achieved
MVHR added	Recover ventilation heat	90.5% effective HR
Triple glazing	Reduce window heat loss	U _w approx. 0.66–0.82
Thermal bridges improved	Reduce junction losses	-0.050 W/mK LETI assumption
Heating distribution improved	Improve ASHP performance	SPF 2.97
Final model	Passive House Classic	15 kWh/m ² a

The upgrade values are based on the LETI-style operational scenario and the upgraded PHPP model (Spring Design, 2024a; King, 2026b). The airtightness target was improved to n50 0.6 1/h to meet the Passive House airtightness target (Passivhaus Trust, 2013; King, 2026b). This is considered achievable for a new-build dwelling where the airtightness line is designed from the start, with service zones, taped penetrations, pre-plaster checks and final pressure testing.

Thermal bridging was the most significant final improvement. The baseline allowance of 0.200 W/mK was first reduced to 0.025 W/mK and then adjusted to the Vale of Glamorgan LETI assumption of -0.050 W/mK for the main junctions (Spring Design, 2024a). This was required to achieve the Passive House Classic heating demand criterion. The internal drain pipe thermal bridge was retained at 0.341 W/mK because it appeared to be a specific service penetration rather than part of the general junction allowance. The LETI value is ambitious and would require junction-by-junction calculations for lintels, sills, jambs, slab edges, eaves, gables, corners and party wall junctions before construction.

The glazing was upgraded to a high-performance triple-glazed system selected from the PHPP component database (Passive House Institute, 2024; King, 2026b). The selected Harbin Sayyas PAZEN window system gives glazing U_g-values of approximately 0.49 W/m²K and installed U_w-values of approximately 0.66–0.82 W/m²K, depending on window size and frame proportion. The component provides a realistic high-performance benchmark, although Final UK availability, warranty, compliance certification and installation support would need to be confirmed with the manufacturer before procurement.

The baseline MEV system was upgraded to MVHR using a Zehnder ComfoAir 225 unit (King, 2026b). The unit heat recovery efficiency was entered as 92%, with PHPP calculating an effective heat recovery efficiency of 90.5% after duct and frost protection assumptions. Short 1m insulated intake and exhaust duct runs were assumed, with 50mm insulation to reduce losses.

The heating strategy was also updated. The PHPP model was changed to a mixed low-temperature emitter system, reflecting ground-floor UFH and first-floor low-temperature radiators. The forward flow temperature was reduced from 55°C to 45°C. PHPP calculated a combined heating and DHW SPF of 2.97, with final electrical energy demand for heat generation of 1,739 kWh/a (King, 2026b). This is conservative compared with the Vale of Glamorgan SCOP of 4.01, because PHPP includes DHW production as well as space heating and uses a standard air-to-water heat pump component (Spring Design, 2024a).

DHW remains important because once space-heating demand is reduced, hot water becomes a larger proportion of the total energy load. The design should use an ASHP-compatible cylinder within the thermal envelope, short insulated pipe runs, time and temperature control and a suitable hygiene cycle.

PV was retained unchanged. The model includes 18 south-facing 400Wp modules, giving an approximate 7.2kWp array and PHPP annual yield of 5,235 kWh/a (Spring Design, 2024a; King, 2026b). No additional PV capacity was added, allowing a fair comparison between baseline and upgraded performance.

7.0 Upgraded PHPP Results

The upgraded PHPP model achieves Passive House Classic verification (King, 2026b).

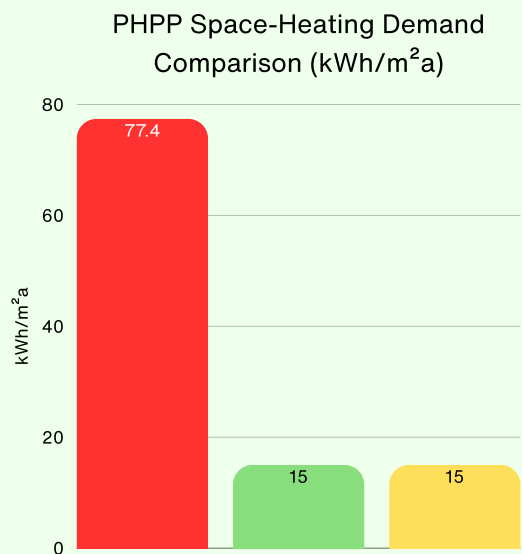


Figure X – Space-heating demand reduced from the baseline model to the upgraded Passive House model.

The results show that the upgrade package reduces space-heating demand from 77.4 kWh/m²a to 15 kWh/m²a, meeting the Passive House Classic heating demand criterion. The model also remains within the overheating, airtightness and PER limits, confirming that the proposed improvements reduce demand without creating an unacceptable summer comfort risk.

PHPP output	Upgraded result	Target / Limit	Status
Treated floor area	101.9m ²		
Space-heating demand	15k Wh/m ² a	≤15k Wh/m ² a	Pass
Heating load	10 W/m ²	≤10 W/m ²	Pass
Airtightness	n50 0.6 1/h	≤0.6 1/h	Pass
Overheating >25°C	5 %	≤10 %	Pass
Excess humidity >12g/kg	20 %	≤20 %	Pass
PER demand	47 kWh/m ² a	≤60 kWh/m ² a	Pass
Renewable generation	71k Wh/m ² footprint	Meets requirement	Pass
Passive House Classic	Yes		Pass

The final model results are taken from the upgraded PHPP verification sheet (King, 2026b).

The results show that the dwelling can meet the selected low-energy standard when the baseline is improved through airtightness, LETI-level thermal bridge detailing, triple glazing, MVHR and low-temperature heat pump distribution. Although overheating increases from 1% to 5%, it remains below the 10% limit, meaning the improved fabric does not create an unacceptable summer comfort risk. This should still be supported by purge ventilation and clear occupant guidance.

The final result is not achieved by adding more PV. The PV provision remains unchanged at 5,235 kWh/a. This demonstrates that the improvement is driven by demand reduction and services optimisation rather than simply increasing renewable generation. This is a stronger Net Zero strategy because it reduces heating load, peak demand and reliance on renewable generation alone.

PHPP Output	Baseline	Upgraded	Improvement
Space-heating demand	77.4 kWh/m ² a	15 kWh/m ² a	-62.4 kWh/m ² a
Heating load	32 W/m ²	10 W/m ²	-22 W/m ²
Airtightness	n50 4.74 1/h	n50 0.6 1/h	Passive House target met
Ventilation	MEV	MVHR 90.5% effective HR	Heat recovery added
Overheating	1%	5%	Below 10% limit
PER demand	46.5 kWh/m ² a	47 kWh/m ² a	Below 60 kWh/m ² a limit
PV generation	5,235 kWh/a	5,235 kWh/a	Retained

Baseline and upgraded results are taken from the respective PHPP models (King, 2026a; King, 2026b).

8.0 Cost, Carbon and Whole-Life Considerations

The proposed upgrades will increase capital cost compared with the baseline. Triple glazing, MVHR, improved airtightness detailing, junction modelling, low-temperature emitter design and enhanced commissioning all require additional design and installation input. These costs should be reviewed against the long-term benefits of lower heating demand, improved comfort and reduced operational energy.

Operational carbon is reduced by lowering demand, improving heat pump operation and retaining PV. Whole-life carbon should also be considered because high-performance glazing, MVHR, ASHP equipment and PV all have embodied carbon (RICS, 2024; UKGBC, 2019). This is particularly relevant because the model uses higher-performance windows, MVHR and PV, which improve operational performance but also increase product-stage impacts. The best design is therefore not simply the one with the most technology, but the one that gives a reliable operational benefit without unnecessary material or services complexity.

Commissioning is critical. The upgraded design relies on airtightness testing, MVHR balancing, heat pump commissioning, emitter balancing, PV commissioning and a clear user handover (Vaillant Group UK Ltd., 2019; Passivhaus Trust, 2024). If these are not completed properly, the actual building may not perform like the PHPP model.

The main performance gap risks are airtightness not achieved on site, MVHR filters not maintained, ASHP flow temperatures set too high, controls being too complicated, and thermal bridge details not being constructed as designed (LETI, 2020; Passivhaus Trust, 2013). To reduce these risks, the final design should include simple controls, as-built commissioning records, occupant guidance and post-occupancy monitoring.

Upgrade	Cost impact	Main benefit	Risk
Airtightness	Low-Medium	Lower heat loss	Site workmanship
MVHR	Medium	Heat recovery / IAQ	Filter maintenance
Triple glazing	Medium-High	Comfort / lower heat loss	Procurement and installation
Thermal bridge detailing	Medium	Required to meet target	Needs psi calculations
ASHP optimisation	Medium	Lower running energy	Commissioning critical
PV retained	Existing	Offsets electricity	Generation/demand mismatch

9.0 Conclusion & Recommendations

The HT641 dwelling is a suitable basis for a low-energy new-build home. The baseline already includes good fabric values, an ASHP and PV, but it remains a compliance-led design. The baseline weaknesses are airtightness, thermal bridging, double glazing, extract-only ventilation, generic ASHP performance and basic controls.

The upgraded PHPP model demonstrates that the dwelling can achieve the Passive House Classic criteria within PHPP (King, 2026b). This is achieved through a coordinated fabric-first and M&E strategy, including airtightness at n50 0.6 1/h, LETI-level thermal bridge detailing, triple glazing, MVHR, low-temperature heating distribution and retained PV generation.

The final recommendation is to adopt the upgraded strategy, subject to detailed psi-value calculations, final heat pump design, manufacturer confirmation and robust commissioning (RICS, 2024; Vaillant Group UK Ltd., 2019). The project should not rely on PV alone. The priority should remain demand reduction, high build quality, efficient services and clear handover to reduce the performance gap and ensure the dwelling performs as intended.

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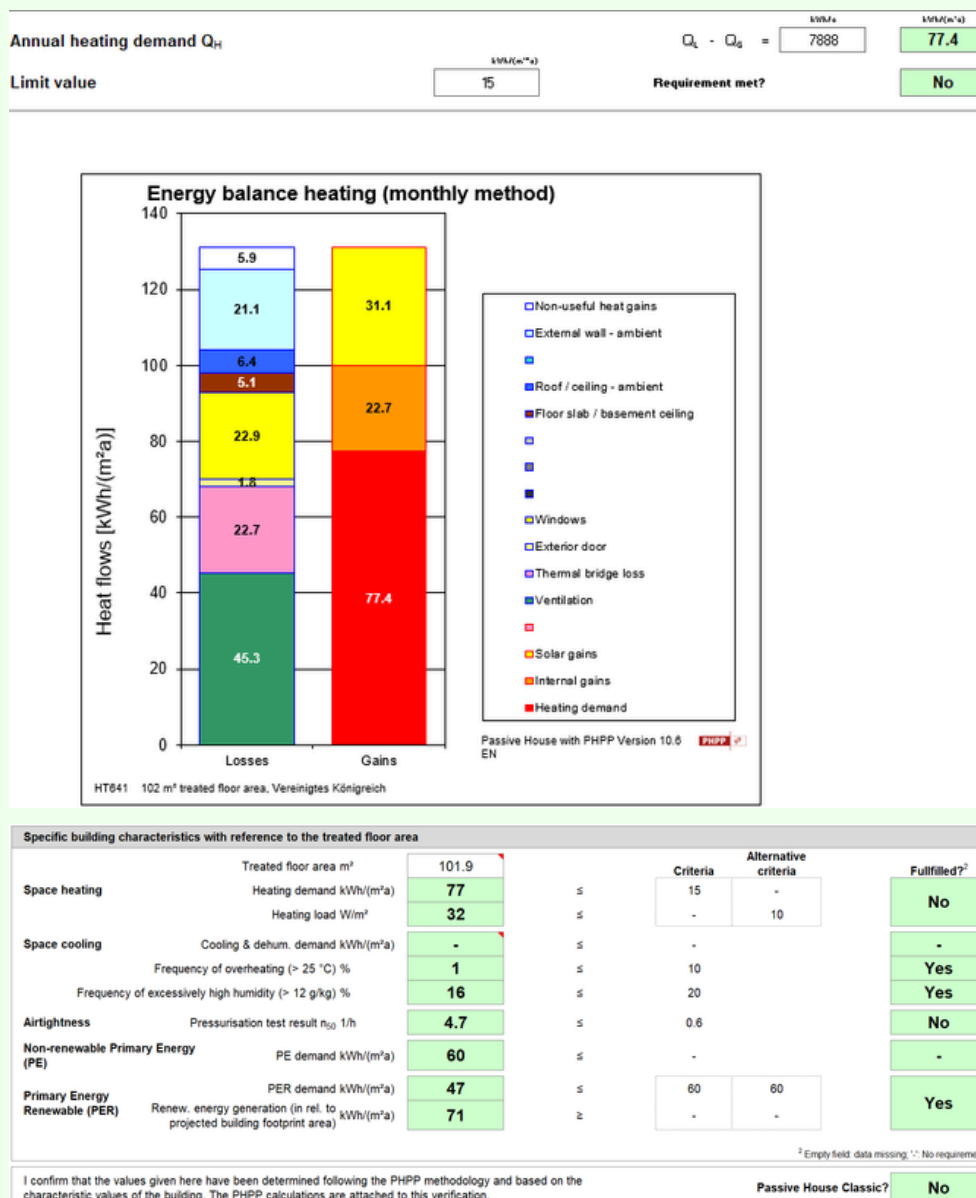
Appendix B- Section 2.1.1 AD: L (Wales) 2025- Showing building make up of HT641

Construction	Size (mm)
Foundations	
Concrete trench fill	600x600
Ground Floor	
Sand & cement screed on 500 gauge polythene separating layer	65
PIR insulation	200
Concrete slab on 1200 gauge polythene damp proof membrane	150
External Walls	
Plasterboard with skim	15
Battens to form service zone	38x47
Passive Purple Internal Vapour Control Paint	
Forterra Evalast aggregate block	100
PIR insulation with all joints taped	165
Ventilated cavity	50
Brickwork	103
Party Walls	
Sand & cement plaster	13
Blockwork	100
Cavity fully filled with ROCKWOOL	50
Blockwork	100
Sand & cement plaster finish	13
Internal Walls	
Wet plaster finish	15
Blockwork	100
Wet plaster finish	15
Intermediate Floor	
Chipboard floor finish	22
SJL45 STEICOjoist partially filled with ROCKWOOL (100mm)	300
Plasterboard with skim	12.5
Separating Floor	
Sand & cement screed	65
Damp proof membrane	0.2
REGUPOL sonus curve 8" resilient layer	
Prestressed concrete beams (50mm concrete topping on 100mm block infill)	150
Metal suspended ceiling system with ROCKWOOL (50mm) over ceiling board	200
Plasterboard with skim	12.5
Roof	
Plasterboard with skim	15
Battens to form service zone over 500 gauge polythene vapour control layer	38x47
Timber ceiling chord fully filled with ROCKWOOL Thermal Insulation Roll	
ROCKWOOL Thermal Insulation Roll	100
Ventilated attic	300
Timber trusses overlaid with breather membrane	
Tile battens	25x38
Concrete tiles	

Appendix B.1 – AD L Wales-style baseline specification used to define the baseline PHPP model, including airtightness, thermal bridge, glazing, ventilation and heating assumptions.

Baseline item	Value
Air permeability	5.00 m³/m²/hr
Thermal bridges	0.200 W/mK
Frame Uf	1.400 W/m²K uPVC
Glazing Ug	1.120 W/m²K double low-e glazing
Glazing g-value	0.64
Glazing edge	0.040 W/mK
Ventilation	MEV
Heat recovery	N/A, extract only
ASHP	Generic
SCOP	3.3
Controls	On/off

Appendix B.2 – Baseline PHPP summary output used as the reference point for comparison with the upgraded LETI model.



Appendix B.3 – Baseline PV assumption showing retained 18-panel PV array and annual PHPP generation output.

Annual electricity yield after the inverter, absolute	5235				Total	5235	kWh/a
Referred to projected building footprint area	71.5				71	71	kWh/m²A _{projected} /a
CO2-equivalent emissions according to 1-CO2 factors GEMIS (Germany)	680.6				680.6	680.6	kg/a
PE-factor according to 1-PE factors (non-renewable) PH Certification	0.00	0.00			0.0	0.00	kWh _{grid} /kWh _{total}

Appendix C.1 – Vale of Glamorgan LETI operational specification used to inform the upgraded PHPP model. The extract identifies the higher-performance assumptions for airtightness, thermal bridging, glazing, MVHR, ASHP and controls.

LETI performance standards were developed by the Low Energy Transformation Initiative (LETI), formerly the London Energy Transformation Initiative, as net zero building standards applying demand-based performance targets within the UK context. Excepting ventilation rate, the values below are not prescribed by LETI but were developed to ensure the least favourable typology (HT 641) could demonstrate compliance.

Building Fabric	
Air permeability	0.50 m ³ /m ² /hr
Thermal bridges	-0.050 W/mK
Doors & Windows	
Frames U _f	0.810-0.088 W/m ² K Rehau Artevo uPVC
Installation thermal bridging	0.009-0.023
Glazing U _g	0.55 W/m ² K triple glazing (4-18Ar-4-18Ar-4)
Glazing g-value	0.63
Glazing edge	0.025 W/mK
Ventilation Strategy	
Ventilation rate	30m ³ per person per hour via MVHR
Ventilation unit	Zehnder ComfoAir 225
Heat recovery efficiency	92%
Ducting	Semi-rigid radial
Duct insulation (inlet/ exhaust)	50mm closed cell Armaflex
Heating	
ASHP	Vaillant aroTHERM plus
SCOP	4.01
Controls	Acc. to ambient temperature

Appendix C.2 – Final upgraded PHPP verification output confirming that the HT641 dwelling meets the Passive House Classic criteria within PHPP.

Specific building characteristics with reference to the treated floor area						
	Treated floor area m ²			Criteria	Alternative criteria	Fulfilled? ²
Space heating	Heating demand kWh/(m ² a)	15	≤	15	-	Yes
	Heating load W/m ²	10	≤	-	10	
Space cooling	Cooling & dehum. demand kWh/(m ² a)	-	≤	-		-
	Frequency of overheating (> 25 °C) %	5	≤	10		Yes
	Frequency of excessively high humidity (> 12 g/kg) %	20	≤	20		Yes
Airtightness	Pressurisation test result n ₅₀ 1/h	0.6	≤	0.6		Yes
Non-renewable Primary Energy (PE)	PE demand kWh/(m ² a)	62	≤	-		-
Primary Energy Renewable (PER)	PER demand kWh/(m ² a)	47	≤	60	60	Yes
	Renew. energy generation (in rel. to projected building footprint area) kWh/(m ² a)	71	≥	-	-	
² Empty field: data missing; -: No requirement						
I confirm that the values given here have been determined following the PHPP methodology and based on the characteristic values of the building. The PHPP calculations are attached to this verification.						Passive House Classic? Yes

Appendix C.3 – Summary of the final upgraded PHPP inputs used to move the model from the AD L-style baseline to the Passive House Classic compliant model.

Upgrade Item	Final PHPP Input / Assumption
Airtightness	n50 0.6 1/h
Thermal bridges	-0.050 W/mK to main junctions, based on LETI scenario assumption
Glazing	Triple glazing, Harbin Sayyas PAZEN system, Ug approx. 0.49 W/m ² K
Installed window performance	Approx. Uw 0.66–0.82 W/m ² K depending on window size and frame proportion
Ventilation	MVHR using Zehnder ComfoAir 225
Effective heat recovery	90.5% PHPP-calculated effective HR
Duct assumptions	1 m intake and exhaust ducts, 50 mm insulation
Heating distribution	Mixed UFH and low-temperature radiators
Flow temperature	45°C
Heat pump SPF	2.97 combined heating and DHW SPF
PV	18 × 400 Wp south-facing modules
Annual PV yield	5,235 kWh/a

The full upgraded PHPP workbook is submitted separately. Appendix C provides only the key extracts needed to evidence the upgrade assumptions and final verification result.